RADIOACTIVE SOLID WASTE TREATMENT – LYNAS EIA

- Domestic waste generated from the workers' camps should be stored in garbage bins/secure containers and be collected regularly by a licensed contractor for disposal at an approved landfill.

- Unsalvageable construction spoil should be stockpiled at a designated site and sold to salvage yard operators or other contractors interested in recycling the material. Alternatively, disposal arrangements can be made with registered private contractors or Majlis Perbandaran Kuantanto carry out regular collection and off site disposal at the approved disposal site.

b. Scheduled Wastes

Types of scheduled wastes potentially generated during the construction phase will require proper handling, storage and disposal in compliance to the scheduled waste regulations. The copies of the waste consignment notes will be filed by the Contractor for record.

The construction works Contractor shall ensure that only licensed scheduled waste contractors are employed for the transportation of these scheduled wastes to the scheduled waste disposal facility, the Integrated Scheduled Waste Management Centre (ISWMC) at Bukit Nanas, Negeri Sembilan.

To prevent potential soil and groundwater, the mitigation measures recommended in **Section 5.5.2.3** shall be applicable.

c. Unregulated Waste

Topsoil refers to soil layers that can be used as a revegetation medium during rehabilitation or landscaping of the site. Topsoils have chemical, physical and biological attributes that assist in the rapid re-establishment of plants as these soils contain a natural stock of seeds and beneficial micro-organisms. Due to their higher organic matter, the excavated soil may be stockpiled within the site and then reused within the 'green' areas proposed at the site.

5.5.3 Operational Phase

5.5.3.1 Potential Sources of Impacts

Solids wastes generated during the operational phase of the Advanced Materials Plant include:

- Residues from the physio-chemical processes within the Cracking & Separation Plant;

- Scale from neutralisation tanks and clarifiers in the Neutralisation Plant;
- Scale from process piping and vessels that handle lanthanide sulphate solution;
- Waste refractory from kiln maintenance;
- Filter cloths from the FGD, NUF and WLP filtration processes;
- Sludge from the Waste Water Treatment Plant (WWTP);
- Scheduled wastes; and
- General wastes.

With the exception of scheduled wastes and general wastes, all other wastes listed above are classified as radioactive wastes by the Atomic Energy Licensing Board (AELB) and thus the storage and management of these wastes must comply with the applicable regulations under the *Atomic Energy Licensing Act, 1984* and, endorsed by the AELB. Matters pertaining to the on-site storage and management of these wastes come under the purview of the Board. Lynas has engaged Malaysian Nuclear Agency (Nuclear Malaysia) as the Radiological Consultants for this project and for the preparation of a Radiological Impact Assessment (RIA) which evaluates the radiological impacts of the plant operations to humans and the environment. A copy of the RIA has been submitted to the AELB for approval as part of the *Class A Milling Licence* application requirements. The Class A Milling Licence is required under the *Atomic Energy Licensing Act, 1984* for plants involved in the processing of radioactive materials.

For purposes of this EIA, only the non-radiological impacts pertaining to the waste management are identified and assessed as the management of radioactive wastes comes under the purview of the AELB (refer **Appendix 1**).

a. Radioactive Wastes

Residues, Refrcatory, Filter Cloths & WWTP Sludge

The three residue streams produced will include:

- Water Leach Purification (WLP) residue resulting from the leaching and purification of the water soluble lanthanide components from the calcined, cracked concentrate in the Cracking & Separation Plant;
- Flue Gas Desulphurisation (FGD) residue from waste gas scrubber system; and

- Neutralization Underflow (NUF) residue from the High Density Sludge system which is the pre-treatment system of the liquid waste streams arising from the Cracking & Separation Plant.

All residue streams and the filter cakes will be stored onsite within the engineered Residue Storage Facility (RSF) until a suitable permanent disposal option is selected by Lynas in conjunction with the AELB. The location of these RSF units is presented in **Exhibit 2.1** (Chapter Two).

Based on the basic engineering design, an estimated 145,200 tons of residues will be generated annually. A summary of the three residue streams in terms of annual dry mass and volume generated, and the state of residue during disposal is presented in **Table 5.5.1**.

Table 5.5.1: Residue Streams Summary

Water Leach-Purification (WLP) solids	32,000	0.70	478,800	Paste
Flue Gas Desulphurisation (FGD) Solids	27,900	1.05	162,600	Paste
Neutralisation Underflow (NUF) Solids	85,300	1.05	91,600	Paste
Total	**145,200**		**2,766,600**	

Notes:
1 *Dewatered residues with water content between 30–40% are referred to as paste.*

Typical compositions and radioactivity of the three residue streams and sludge from the WWTP are shown in **Table 5.5.2.**

Table 5.5.2: Major Waste Composition of the Residue Streams and Sludge from the WWTP

Iron Oxide	19.74	0.16	0.17	2.4
Phosphorus Oxide	19.77	0.00	0.00	0.3
Aluminium Oxide	2.86	0.12	0.23	0.4
Calcium Oxide	1.36	28.39	22.31	-
Magnesium Oxide	0.03	0.00	7.06	4.2
Manganese Oxide	0.37	0.00	0.37	-
Barium Oxide	0.3	-	-	0.01
Sulphite	0.00	0.00	0.03	-
Zinc	0.1	-	-	-
Strontium Oxide	0.4	-	-	-
	ppm	**ppm**	**ppm**	**ppm**
Fluoride	-	1800	-	71
Thorium Oxide	1655	0.00	0.00	26
Uranium Oxide	22.5	-	-	1.1
Sodium Oxide	-	0.00	0.13	36
Potassium Oxide	-	0.00	0.00	28
	Bq/g	**Bq/g**	**Bq/g**	**Bq/g**
Radiation (Specific Activity)	62.0	0.47	0.25	1.1

** Note: Sludge is from Wastewater Treatment Plant*

Scales

Calcium sulfate scale from the neutralisation tanks and clarifiers in the HDS Neutralisation Plant have similar physico-chemical characteristics as the NUF solids and will be disposed of in the NUF cell of the RSF.

Calcium sulfate scale from process piping and vessels that handle the lanthanide sulphate solution primarily consists of calcium sulphate and low levels of radium, and will be disposed of at the WLP solids cell of the RSF.

Waste Kiln Refractory and Filter Cloths

Waste refractory from kiln maintenance (which will be generated at an estimated 5 – 50 tonnes every two years) and filter cloths from filtration processes (estimated at 5 – 50 tons per annum) may exhibit low levels of radioactivity and will be disposed of at the RSF.

b. Scheduled Wastes

Scheduled wastes generated from site operations are anticipated to include:

- Used engine, hydraulic and lubricating oil from maintenance workshop and general lubricating and maintenance activities;
- Used batteries from vehicles and equipment;
- Discarded or off-specification chemicals (including acids, alkalis and reagents used);
- Containers, bags or equipment contaminated with chemicals or mineral oil; and
- Rags, plastics, papers or filters contaminated with chemicals or oils.

c. General Waste

General/municipal wastes arising from the operation of the plant include canteen waste, office wastes from the administration offices and miscellaneous wastes from other working areas which may include, waste paper, plastic, cardboards etc.

5.5.3.2 Assessment of Impacts

a. Radioactive Wastes

Potential environmental impacts associated with on-site residue storage (RSF) include:

- Soil and groundwater contamination; and
- Residue embankment slope stability and erosion problems.

As shown in **Table 5.6.2** the residues are primarily composed of oxides of iron, aluminium, silicon, magnesium, calcium and phosphorus. These are compounds that are readily found as major constituents that make up soil minerals.

The complete environmental impact assessment of these radioactive wastes will be undertaken as part of the Radiological Impact Assessment by the Malaysian Nuclear Agency for submission to the Atomic Energy Licensing Board.

The potential leaching of trace metals, including radioactive lanthanide metals, from the residues may result in contamination of the underlying soil and groundwater resources.

It is noted that there are no groundwater abstraction points or direct groundwater users have been identified on-site or at immediate down-gradient locations. Additionally, there are no other potentially sensitive groundwater receptors within the zone of impact.

Residue embankment slope stability and erosion may also result in release of residues outside of lined cells and pose a potential health and safety problem in addition soil and groundwater contamination. A preliminary embankment slope stability assessment has been conducted based on the subsurface profile encountered during the site investigation and estimated design parameters in order to ensure the factor of safety (FOS) of slopes against global failure. In accordance with ANCOLD (Australian National Committee on Large Dams) guidelines the required FOS for short-term and long-term stability are 1.3 and 1.5, respectively. The preliminary slope stability assessment indicates that the FOS against global failures for embankment height up to 8m is acceptable in the long term case but not the short term case. Slope stability impacts should be appropriately addressed (see Section 5.5.3.3).

b. Scheduled Wastes

The primary concern with regards to scheduled waste management is spillages which will potentially contaminate surface-runoff, soil and groundwater.

Based on the types of scheduled waste potentially generated from the site, the quantities will not be significant. These wastes can be sold to scheduled waste recycling contractors who are licensed by DOE. The impacts arising from the storage and handling of the scheduled wastes categories identified are not significant.

5.5.3.3 Recommended Mitigation Measures

a. Radioactive Wastes

In ensuring that the potential environmental impacts arising from the on-site storage of the radioactive residue streams are minimised to a sustainable level, Lynas has developed a technically sound waste management strategy which is described Section 3.2 *'Preliminary Comparison of Residue Disposal Options'* (Refer **Appendix 3)**. It is recommended that this strategy be incorporated into the Environmental Management Plan (EMP) prepared for operational phase and endorsed by the AELB and the DOE for implemention. The waste management strategy developed by Lynas is directed towards the design of an environmentally sustainable residue storage facility (RSF) while maximizing the potential for recycling or reuse of each residue stream back into the process.

The Project Proponent has commissioned a conceptual engineering design of the RSF, taking into account key engineering design and environmental considerations. Each residue stream has different characteristics in terms of water content, its composition and radioactivity. Design considerations of the RSF as well as residue management are dependent on these characteristics. One conceptual design scenario has been presented to the AELB and are currently under evaluation.

The key features of the RSF design which provides for the protection of environmental resources, namely soil and groundwater are summarised below:

- Fill material will be placed at low-lying areas to ensure that the base of the RSF is at least 1 m above groundwater level. It is recommended that the fill material comprises soils with low permeability;

- All residue storage cells will be lined with 300 mm low permeability compacted clay liner overlain by a 1 mm thick HDPE liner to prevent seepage into the underlying soil and groundwater;

- All supernatant liquors and rainfall runoff from FGD and NUF residue cells will be collected and pumped via pipeline to a HDPE-lined FGD/NUF surface water retention pond with capacity for the 1 in 100 year storm event based on climatic data for the region. Water from this pond will be directed to the Waste Water Treatment Plant (WWTP). The treated waste water will then be discharged off-site into an external earth drain which discharges into Sungai Balok. All off-site discharges will be monitored to comply with the limits stipulated in *Standard B* of the *Environmental Quality (Sewage and Industrial Effluent) Regulations, 1979*;

- Supernatant liquors and rainfall runoff from the WLP residue cell will be pumped to a separate HDPE lined surface water retention pond (with capacity for the 1 in 100 year storm event based on climatic data for the region) and subsequently recycled into the cracking and separation process stream. No off-site discharge is anticipated;

- During heavy rainfall and in particular the monsoonal wet season the surface of the residue is expected to become wet, soft and slippery making placement of residue during this period problematic due to the poor trafficability of the residue surface. Therefore, a temporary cover may be required to keep the area of active residue placement dry during the wet season. A potential solution to this problem is to size the drying shed with sufficient capacity so residue can be stockpiled during the wet season awaiting placement in the RSF during drier weather;

- To ensure a long term slope stability, perimeter RSF embankment walls will be designed and built with a gentle gradient of 3H:1V. In addition, the maximum height of embankment will be limited to 8 m above existing ground level. The preliminary slope stability assessment indicates that the proposed embankment fill height of 8m results in a FOS of less than the acceptable minimum of 1.3 under short-term undrained conditions. This can be overcome by the placement of an additional 1.0m of well compacted select fill across the RSF area. Further assessment of the consolidation behaviour of the subsurface soils is required to confirm the short-term stability of the embankments; and

- Erosion protection in the form of rip-rap or geotextiles will be incorporated.

A conceptual cross-sectional design of the RSF showing liner and embankment details are provided in **Exhibits 5.5.1 – 5.5.4.**

In addition to constructing the RSF which incorporates environmental protection features, the Project Proponent is also exploring the potential beneficial uses of each of the three residue streams. The reuse of residues will significantly reduce the quantity of residue for on-site storage and the allocated footprint for the RSF within the site. Details of these reuse options are presented in the *'Preliminary Comparison of Residue Disposal Options'* presented in **Appendix 3**.

A summary of these end uses are presented in **Table 5.5.3** below.

Table 5.5.3: Summary of Potential Residue End Uses

Residue Stream	Potential Residue End Uses
Water Leach-Purification (WLP) residue	• Fertilizer (high levels of phosphorus and magnesium) • Raw material for Cement manufacture
Flue Gas Desulphurisation (FGD) residue	• Plasterboard market (calcium sulphate) • Raw material for cement manufacture
Neutralisation Underflow (NUF) residue	• Fertilizer (high levels of magnesium, aluminium and calcium sulphate) • Raw material for cement manufacture

In addition, the design, construction and operation of the RSF must be monitored and carried out so that it does not result in adverse impacts identified in the previous section. Prevention and control measures include the following:

- RSF surface water retention ponds should be sized to accommodate monsoon and storm events over the life of the project;

- A detailed settlement and slope stability including seismic sensitivity analyses to ensure the stability of the landform created should be considered;

- During the construction of the RSF, QA/QC procedures should be implemented to ensure that the liner system of the RSF is installed without any compromise to its integrity. This includes on-site full time supervision of a qualified engineer during liner installation and strict quality inspection checks;

- Frequent inspection and maintenance of the surface runoff and leachate collection and treatment systems must be carried out to ensure continuous operation, particularly during the wet season;

- Monitoring of groundwater quality in the vicinity of the RSF should be conducted on a regular basis. More groundwater monitoring wells should be installed at strategic locations to detect potential groundwater contamination;

- Access to the RSF should be restricted to authorized personnel only and appropriate personal protective equipment (PPE) must be worn to reduce the risk of potential exposure to low level radiation and other contaminants from the residues; and

- A *RSF Management Plan* which covers aspects of residue deposition, rainfall runoff management, dust generation and entrainment, environmental monitoring, health and safety as well as site closure and rehabilitation should be developed and implemented as part of the EMP prepared for the operational phase of the plant.

As part of the fill/construct methodology for the RSF, cells will be capped once design capacity is achieved creating a landform with positive drainage. Capping is envisaged to comprise a 500mm thick rock-fill layer to serve as a capillary break, overlain by low permeability clayey soil and topsoil to lower the risk of infiltration. Interaction between rainfall and surface water runoff from capped cells and permanently stored residues will be minimised and the final site topography will encourage surface water to drain off-site to prevent ponding and standing water.

b. Scheduled and General Waste

Scheduled wastes generated from plant operations will require proper handling, storage and disposal. These practices shall meet the requirements stipulated in the *Environmental Quality (Scheduled Waste) Regulations, 2005.*

Scheduled wastes generated at the site can either be recycled or disposed at approved facilities. There is currently a market of spent oils, solvents, lead batteries, oil filters and paints. These can be readily sold to DOE-licensed recyclers. There are a few facilities licenced to recover spent catalyst, waste oil, spent hydraulic oil and chemicals that are discarded or off-specification located nearby in the Gebeng Industrial Area and Teluk Kalong Industrial Area.

Scheduled wastes which cannot be recycled but require disposal will need to be disposed at the Integrated Scheduled Waste Management Center (ISWMC) operated by Kualiti Alam which is presently the only licensed facility in Malaysia. Upon signing a contract with Kualiti Alam, the company will arrange for their marketing division to coordinate the entire packaging and transportation of the wastes to the integrated facility.

Specifications for scheduled waste storage (pending off-site removal) have been stipulated in the Regulations. The wastes shall be stored within a designated storage area and the design of the storage area shall comply with the requirements of the Regulations.

Salient features of the design include:

- Provision of hardstanding, with impervious flooring (such as concrete);
- A bund wall capable of containing 110% of the contents of the largest storage tank volume in the event of spill;
- The discharge outlet of the bunded area must be appropriately designed (e.g. with valve) so that there is no direct discharge or release of material away from the storage area;
- Preferably constructed with walls and roof to protect against the weather (sun and rainwater ingress);
- Well-ventilated and well-lit;
- Incompatible scheduled wastes must be stored in separate containers and placed in separate secondary containment areas; and
- Locked when access is not required and should be accessible only to authorized persons.

Other key requirements of the regulations are as follows:

- DOE shall be notified on the generation of the scheduled waste within the facility;

- Up to date inventories of the scheduled waste generated, treated and disposed of are to be maintained for inspection by DOE;
- All storage bins/areas should be properly labelled and identified. Storage of incompatible wastes is prohibited;
- The off-site transport of scheduled wastes from the point of generation to the final disposal facility must utilise the Consignment Note System; and
- The waste generator is responsible for informing the (DOE-licensed) waste transport contractor on the nature of the waste and of the precise actions necessary to preserve human life and the environment in the event of an accident during the transport.

5.6 AMBIENT AIR

5.6.1 Regulatory Requirements

Industrial gaseous emissions are regulated by the *Environmental Quality (Clean Air) Regulations 1978*. Under these Regulations, industrial facilities are required to comply with three types of standards: A, B and C under the *Stack Gas Emission Standards* specified under sub-regulation 27.

All new operations are required to comply with Standard C, while Standards A and B are applicable for operations which commenced prior to the promulgation of this regulation in 1978. These standards are regarded as acceptable conditions for air emissions in Malaysia. The standards are given based on the sources of emission for certain activity or from "any other sources", which is normally applicable for most manufacturing industries. No standards have been listed specifically for general manufacturing operations although standards exist for sulphuric acid mist/sulphur trioxide, solid particles, metal and metallic compounds, chlorine gas, hydrogen chloride, fluorine, hydrofluoric acid, inorganic fluorine compound, hydrogen sulphide and oxides of nitrogen from "any source". The limits prescribed are presented in **Table 5.6.1.**

Any erection, installation, re-siting or alteration of fuel burning equipment or of a chimney, from or through which air impurities may be emitted or discharged, will require a Written Approval from the DOE Pahang State office. This includes the installation of boilers and emergency/back-up generators that are rated to consume any liquid or gaseous matter at or more than 15 kg or more per hour. The application for the Written Approval can be made to the DOE State office using Form AP/E/1/98. Information to be provided in the application form include design and operational details of the fuel burning equipment/chimney/pollution control equipment. The processing duration for the Written Approval is approximately 1 month.